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NATIONAL DAM SAFETY PROGRAM. GUILFORD LAKE DAM (MO 31137), MISS--ETC(U)
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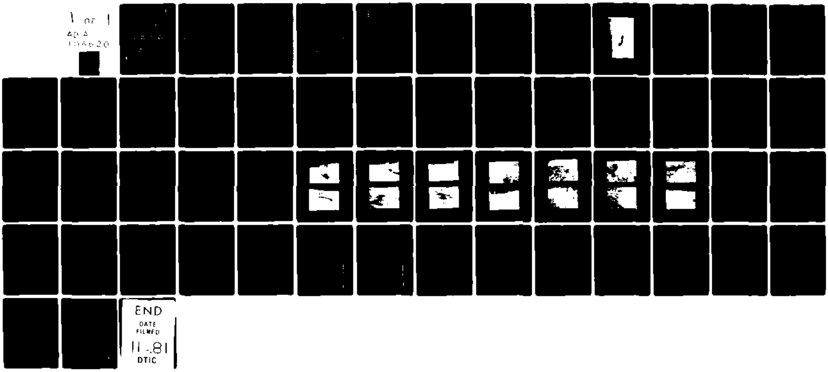

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GUILFORD LAKE DAM

ST. LOUIS COUNTY, MISSOURI

MO 31137

PHASE 1 INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

United States Army
Corps of Engineers
...Serving the Army
...Serving the Nation

St. Louis District

PREPARED BY: U.S. ARMY ENGINEER DISTRICT. ST. LOUIS

FOR: STATE OF MISSOURI

NOVEMBER 1980

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REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER	2. GOVT ACCESSION NO. AD-A106 620	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) Phase I Dam Inspection Report National Dam Safety Program Guilford Lake Dam (MO 31137) St. Louis County, Missouri		5. TYPE OF REPORT & PERIOD COVERED Final Report
		6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) Black & Veatch, Consulting Engineers		8. CONTRACT OR GRANT NUMBER(s) DACW43-80-C-0074
9. PERFORMING ORGANIZATION NAME AND ADDRESS U.S. Army Engineer District, St. Louis Dam Inventory and Inspection Section, LMSED-PD 210 Tucker Blvd., North, St. Louis, Mo. 63101		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
11. CONTROLLING OFFICE NAME AND ADDRESS U.S. Army Engineer District, St. Louis Dam Inventory and Inspection Section, LMSED-PD 210 Tucker Blvd., North, St. Louis, Mo. 63101		12. REPORT DATE November 1980
		13. NUMBER OF PAGES Approximately 45
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)		15. SECURITY CLASS. (of this report) UNCLASSIFIED
		15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for release; distribution unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Dam Safety, Lake, Dam Inspection, Private Dams

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This report was prepared under the National Program of Inspection of Non-Federal Dams. This report assesses the general condition of the dam with respect to safety, based on available data and on visual inspection, to determine if the dam poses hazards to human life or property.

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SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

MISSISSIPPI-KASKASKIA-ST. LOUIS BASIN

GUILFORD LAKE DAM
ST. LOUIS COUNTY, MISSOURI
MO 31137

PHASE 1 INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM.

Guilford Lake Dam (MO 31137),
Mississippi - Kaskaskia - St. Louis Basin,
St. Louis County, Missouri. Phase I
Inspection Report.

United States Army
Corps of Engineers
...Serving the Army
...Serving the Nation

St. Louis District

9 Final rept.,

15 DACW43-80-C-0074

10 Edwin R. /Burton
Harry L. /Callahan

PREPARED BY: U.S. ARMY ENGINEER DISTRICT. ST. LOUIS

FOR: STATE OF MISSOURI

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DEPARTMENT OF THE ARMY

ST. LOUIS DISTRICT, CORPS OF ENGINEERS
210 TUCKER BOULEVARD, NORTH
ST. LOUIS, MISSOURI 63101

REPLY TO
ATTENTION OF

SUBJECT: Dam Phase I Inspection Report

This report presents the results of field inspection and evaluation of the Guilford Lake Dam (MO 31137).

It was prepared under the National Program of Inspection of Non-Federal Dams.

This dam has been classified as unsafe, non-emergency by the St. Louis District as a result of the application of the following criteria:

a. Spillway will not pass 50 percent of the Probable Maximum Flood without overtopping the dam.

b. Overtopping of the dam could result in failure of the dam.

c. Dam failure significantly increases the hazard to loss of life downstream.

SUBMITTED BY: SIGNED — 29 APR 1981
Chief, Engineering Division — Date

APPROVED BY: SIGNED — 30 APR 1981
Colonel, CE, District Engineer — Date

GUILFORD LAKE DAM

ST. LOUIS COUNTY, MISSOURI

MISSOURI INVENTORY NO. 31137

PHASE I INSPECTION REPORT

NATIONAL DAM SAFETY PROGRAM

PREPARED BY:

BLACK & VEATCH
CONSULTING ENGINEERS
KANSAS CITY, MISSOURI

UNDER DIRECTION OF

ST. LOUIS DISTRICT CORPS OF ENGINEERS

FOR

GOVERNOR OF MISSOURI

NOVEMBER 1980

PHASE I REPORT

NATIONAL DAM SAFETY PROGRAM

Name of Dam	Guilford Lake Dam
State Located	Missouri
County Located	St. Louis County
Stream	Tributary of Fox Creek
Date of Inspection	19 November 1980

Guilford Lake Dam was inspected by a team of engineers from Black & Veatch, Consulting Engineers for the St. Louis District, Corps of Engineers. The purpose of the inspection was to make an assessment of the general condition of the dam with respect to safety, based upon available data and visual inspection, in order to determine if the dam poses hazards to human life or property.

The guidelines used in the assessment were furnished by the Department of the Army, Office of the Chief of Engineers and developed with the help of several Federal and state agencies, professional engineering organizations, and private engineers. Based on these guidelines, this dam is classified as a small size dam with a high downstream hazard potential. According to the St. Louis District, Corps of Engineers, failure would threaten lives and property. The estimated damage zone extends approximately two miles downstream of the dam. Within the estimated damage zone are eight dwellings, several farm buildings, and State Highway 100. Contents of the estimated downstream damage zone were verified by the inspection team.

Our inspection and evaluation indicates that the spillway does not meet the criteria set forth in the guidelines for a dam having the above size and hazard potential. The spillway will not pass the probable maximum flood without overtopping but will pass 15 percent of the probable maximum flood. The spillway will pass the flood which has a one percent chance of occurrence in any given year (100-year flood). The spillway design flood recommended by the guidelines is 50 to 100 percent of the probable maximum flood. Considering the hazard zone and the volume of water stored, the spillway design flood should be 50 percent of the probable maximum flood. The probable maximum flood is defined as the flood discharge which may be expected from the most severe combination of critical meteorologic and hydrologic conditions which are reasonably possible in the region.

Based on visual observations, this dam appears to be in good condition. Deficiencies visually observed by the inspection team were poor erosion protection on the embankment, erosion of the right (southwest) bank of the spillway channel, erosion of the left (northeast) abutment, and erosion of the right (southwest) abutment below the spillway. Seepage and stability analyses required by the guidelines were not available.

There were no observed deficiencies or conditions existing at the time of the inspection which indicated an immediate safety hazard. Future corrective action and regular maintenance will be required to correct or control the described deficiencies. In addition, detailed seepage and stability analyses of the existing dam, as required by the guidelines, should be performed. A detailed report discussing each of these deficiencies is attached.

Edwin R Burton

Edwin R. Burton, PE
Missouri E-10137

Harry L Callahan

Harry L. Callahan, Partner
Black & Veatch

OVERVIEW OF DAM

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM
GUILFORD LAKE DAM

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SECTION 1 - PROJECT INFORMATION

1.1 GENERAL

a. Authority. The National Dam Inspection Act, Public Law 92-367, authorized the Secretary of the Army, through the Corps of Engineers, to initiate a program of safety inspection of dams throughout the United States. Pursuant to the above, the District Engineer of the St. Louis District, Corps of Engineers, directed that a safety inspection of the Guilford Lake Dam be made.

b. Purpose of Inspection. The purpose of the inspection was to make an assessment of the general condition of the dam with respect to safety, based upon available data and visual inspection, in order to determine if the dam poses hazards to human life or property.

c. Evaluation Criteria. Criteria used to evaluate the dam were furnished by the Department of the Army, Office of the Chief of Engineers, in "Recommended Guidelines for Safety Inspection of Dams." These guidelines were developed with the help of several Federal agencies and many state agencies, professional engineering organizations, and private engineers.

1.2 DESCRIPTION OF PROJECT

a. Description of Dam and Appurtenances.

(1) The dam is an earth structure located in the valley of a tributary to Fox Creek (See Plate 1). The watershed is an area of low hills with fairly steep slopes consisting of about 65 percent timberland and 35 percent grassland pastures. There are several large houses in the drainage area. The dam is approximately 350 feet long along its crest and is constructed with a curved alignment. The dam is about 32 feet high and is 11 feet wide at its crest. The downstream face of the dam has a nonuniform slope from the crest to the valley floor below.

(2) The spillway is an unlined open channel cut in the natural material of the right abutment. The material excavated from the spillway channel forms a dike along the left bank of the spillway. The spillway channel is nonuniform in width and cross section with an approximate average depth of 4 feet and an approximate average bottom width of 7 feet. Flow through the spillway channel discharges to the natural slope of the abutment then to the stream channel below the dam.

(3) Pertinent physical data are given in paragraph 1.3.

b. Location. The dam is located in western St. Louis County, Missouri, as indicated on Plate 1. The lake formed by the dam is in an area shown on the United States Geological Survey 7.5 minute series quadrangle map for Eureka, Missouri in Section 19 of T44N, R03E.

c. Size Classification. Criteria for determining the size classification of dams and impoundments are presented in the guidelines referenced in paragraph 1.1c above. Based on these criteria, the dam and impoundment are in the small size category. A small size dam is classified as having a height less than 40 feet, but greater than or equal to 25 feet and/or a storage capacity less than 1,000 acre-feet, but greater than or equal to 50 acre-feet.

d. Hazard Classification. The hazard classification assigned by the Corps of Engineers for this dam is as follows: The Guilford Lake Dam has a high hazard potential, meaning that the dam is located where failure may cause loss of life, and serious damage to homes, agricultural, industrial and commercial facilities, and to important public utilities, main highways, or railroads. For the Guilford Lake Dam the estimated flood damage zone extends approximately two miles downstream of the dam. Within the estimated damage zone are eight dwellings, several farm buildings, and State Highway 100. Contents of the estimated downstream damage zone were verified by the inspection team.

e. Ownership. The dam is owned by Mr. Charles F. Guilford, Rural Route 5, Pacific, Missouri 63069.

f. Purpose of Dam. The dam forms a 4.5-acre lake used for recreation and as a livestock water supply.

g. Design and Construction History. Data relating to the design and construction were not available. The dam was constructed in 1976 by Kenneth Pointer with design assistance from the Soil Conservation Service.

h. Normal Operating Procedure. Normal rainfall, runoff, transpiration, evaporation, and overflow through the uncontrolled spillway all combine to maintain a relatively stable water surface elevation.

1.3 PERTINENT DATA

a. Drainage Area - 26 acres

b. Discharge at Damsite.

(1) Normal discharge at the damsite is through an unlined, open channel spillway.

(2) Estimated experienced maximum flood at damsite - Unknown.

(3) Estimated ungated spillway capacity at maximum pool elevation 60 cfs (50 Percent Probable Maximum Flood Pool El. 690.9).

c. Elevation (Feet above m.s.l. Approximated from USGS Map contours).

(1) Top of dam - 690.0 (see Plate 3)

(2) Spillway crest - 689.0

(3) Streambed at toe of dam - 658.5

(4) Maximum tailwater - Unknown.

d. Reservoir.

(1) Length of maximum pool - 790 feet ± (Probable maximum flood pool level).

(2) Length of normal pool - 590 feet ± (Spillway crest).

e. Storage (Acre-feet).

(1) Top of dam - 52

(2) Spillway crest - 46

(3) Design surcharge - Not available.

f. Reservoir Surface (Acres).

(1) Top of dam - 5.7

(2) Spillway crest - 4.5

g. Dam.

(1) Type - Earth embankment.

(2) Length - 350 feet

(3) Height - 32 feet ±

(4) Top width - 11 feet

(5) Side slopes - upstream face 1.0 V on 3.4 H, downstream face varies between 1.0 V on 2.5 H and 1.0 V on 5.0 H (see Plate 4).

(6) Zoning - Unknown.

(7) Impervious core - Unknown.

(8) Cutoff - Unknown.

(9) Grout curtain - Unknown.

h. Diversion and Regulating Tunnel - None.

i. Spillway.

(1) Type - Unlined, open channel with an approximate 7-foot bottom width and 4-foot height.

(2) Crest elevation - 689.0 feet m.s.l.

(3) Gates - None.

(4) Upstream channel - Unlined earth channel.

(5) Downstream channel - Spillway discharges to natural slope, then to the natural stream downstream of the dam.

j. Emergency Spillway - None.

k. Regulating Outlets - None.

SECTION 2 - ENGINEERING DATA

2.1 DESIGN

Design data were not available. Design assistance was provided by the Soil Conservation Service.

2.2 CONSTRUCTION

Construction records were unavailable. The dam was constructed by Kenneth Pointer.

2.3 OPERATION

Operational records and documentation of past floods were unavailable.

2.4 GEOLOGY

The site of the dam and reservoir is located in a shallow, broad, steep-sided valley. The dam impounds a very short, intermittent tributary of Fox Creek.

There were no data available on the soils in the area of the dam and reservoir. The bedrock consists of limestone of the Osage series of the Pennsylvanian System according to the Geologic Map of Missouri.

2.5 EVALUATION

a. Availability. No engineering data were available.

b. Adequacy. No engineering data were available. Thus, an assessment of the design, construction, and operation could not be made. Seepage and stability analyses comparable to the requirements of the "Recommended Guidelines for Safety Inspection of Dams" were not available, which is considered a deficiency. These seepage and stability analyses should be performed for appropriate loading conditions (including earthquake loads) and made a matter of record.

c. Validity. The validity of the design, construction, and operation could not be determined due to the lack of engineering data.

SECTION 3 - VISUAL INSPECTION

3.1 FINDINGS

a. General. A visual inspection of Guilford Lake Dam was made on 19 November 1980. The inspection team consisted of Edwin Burton, team leader; Robert Pinker, geologist; Gary Van Riessen, geotechnical engineer; and John Ruhl, civil engineer. The dam appeared to be in good condition. Specific observations are discussed below. No observations were made of the condition of the upstream face of the dam below the pool elevation at the time of the inspection.

b. Dam. The inspection team observed the following conditions at the dam. No cracking, sliding, sloughing, unusual irregularities, or other signs of instability or settlement were observed. The grass cover on the dam was very thin to nonexistent in spots. Numerous tracks of cattle and horses were observed which would indicate heavy grazing. There were no trees on the embankment. Small riprap (approximately 3-6 inches in size) has been placed on the upstream face at the waterline. The soft upstream face for several feet above the waterline would indicate that the water level had been higher a short time before the inspection. Erosion exists along the left abutment where runoff from the road and hillside drains into the lake and on the right abutment below the end of the spillway channel. Minor erosion was observed on the downstream slope of the embankment. No areas of seepage were observed. Although the old stream channel was very green, the inspection team believes that this is due to surface drainage rather than seepage. A void exists in the fill material in the old stream channel. There were no animal burrows observed on the embankment. Although the owner stated that the dam was overtopped in 1978 there were no visible signs of overtopping.

c. Appurtenant Structures. The inspection team observed the following items pertaining to the appurtenant structures. The spillway was in good condition. The right bank of the spillway channel is eroding from hillside runoff. Although the grass cover is unsatisfactory, there has been no erosion of the channel floor. There was no development in the spillway area which would suffer damage due to flow through the spillway.

d. Geology. The soils observed in the area of the dam and reservoir consist of silty clay formed in residuum from limestone. For engineering purposes the soils are classified as clayey silt or silty clay of low plasticity. No outcrops were observed in the area. However numerous fragments of chert were present in the soils and on the embankment. A sample of the material in the embankment was taken with an Oakfield sampler near the center of the downstream crest. The materials

sampled consisted of silty clay and were visually classified for engineering purposes as silty clay of low plasticity (CL). Based on these samples, it is surmized that the embankment is constructed of silty clay (CL).

e. Reservoir Area. No slumping or slides of the reservoir banks were observed. Drainage into the reservoir is primarily runoff from the steeply sloping hills around the lake with little defined channelized flow. There was no noticeable lake siltation.

f. Downstream Channel. The spillway discharges to the natural slope, then flows overland to the natural stream channel downstream of the dam. The stream channel has been filled for approximately 200 feet downstream of the toe of the dam.

3.2 EVALUATION

The various deficiencies observed at the time of the inspection are not believed to represent an immediate safety hazard. They do, however, warrant monitoring and control.

The thin grass cover on the embankment and in the spillway has permitted the erosion of the right spillway bank, the right abutment below the spillway, and the left abutment. Each of these areas of erosion should be repaired and adequate erosion protection should be maintained.

SECTION 4 - OPERATIONAL PROCEDURES

4.1 PROCEDURES

The pool is primarily controlled by rainfall, runoff, evaporation, transpiration, and capacity of the uncontrolled spillway.

4.2 MAINTENANCE OF DAM

According to the owner, the dam was overtopped in 1978 due to blockage of the spillway. Subsequently, the blockage was removed and the embankment was redressed and seeded. No other maintenance has been performed.

4.3 MAINTENANCE OF OPERATING FACILITIES

No operating facilities exist.

4.4 DESCRIPTION OF ANY WARNING SYSTEM IN EFFECT

There is no existing warning system or preplanned scheme for alerting downstream residents for this dam.

4.5 EVALUATION

A maintenance program should be established to provide adequate erosion protection of the spillway and embankment.

SECTION 5 - HYDRAULIC/HYDROLOGIC

5.1 EVALUATION OF FEATURES

a. Design Data. No design data were available.

b. Experience Data. The drainage area and the lake surface area are developed from the USGS Eureka, Missouri Quadrangle Map. The dam layout is from a survey made during the inspection.

c. Visual Observations.

(1) The spillway appears to be in good condition. The lake level at the time of the inspection (El. 685.0) was below the spillway crest level. There were no obstructions to flow in the downstream channel.

(2) There is no emergency spillway for this dam.

(3) Large spillway discharges will probably erode the spillway and could erode the embankment.

d. Overtopping Potential. The spillway will not pass the probable maximum flood without overtopping the dam. The probable maximum flood is defined as the flood discharge that may be expected from the most severe combination of critical meteorologic and hydrologic conditions that are reasonably possible in the region. The spillway will pass 15 percent of the probable maximum flood without overtopping the dam. The spillway will pass the one percent chance flood estimated to have a peak outflow of 19 cfs developed by a 24-hour, one percent chance rainfall. According to the recommended guidelines from the Department of the Army, Office of the Chief of Engineers, a high hazard dam of small size should pass 50 to 100 percent of the probable maximum flood. Considering the downstream hazard, and the volume of water stored, the appropriate spillway design flood should be 50 percent of the probable maximum flood. The portion of the estimated peak discharge of 50 percent of the probable maximum flood overtopping the dam would be 150 cfs of the total discharge from the reservoir of 210 cfs. The estimated duration of overtopping is 5.6 hours with a maximum height of 0.9 feet. The portion of the estimated peak discharge of the probable maximum flood overtopping the dam would be 420 cfs of the total discharge from the reservoir of 530 cfs. The estimated duration of overtopping is 7.2 hours with a maximum height of 1.4 feet. The embankment could be jeopardized should overtopping occur for these periods of time.

According to the St. Louis District, Corps of Engineers, the effect from rupture of the dam could extend approximately two miles downstream of the dam. Within the estimated damage zone are eight dwellings, several farm buildings, and State Highway 100. Contents of the estimated

downstream damage zone were verified by the inspection team. Flood plain regulations under the National Flood Insurance Program restrict development in the flood plain of Fox Creek which is downstream of the dam.

SECTION 6 - STRUCTURAL STABILITY

6.1 EVALUATION OF STRUCTURAL STABILITY

a. Visual Observations. Visual observations of conditions which affect the structural stability of this dam are discussed in Section 3, paragraph 3.1b.

b. Design and Construction Data. No design data relating to the structural stability of the dam were found. Seepage and stability analyses comparable to the requirements of the "Recommended Guidelines for Safety Inspection of Dams" were not available, which is considered a deficiency.

c. Operating Records. No operational records exist.

d. Postconstruction Changes. Repair of erosion due to overtopping included redressing and seeding the embankment crest and slopes. The repairs were made in 1979.

e. Seismic Stability. The dam is located in Seismic Zone 2 which is a zone of moderate seismic risk. A properly designed and constructed earth dam using sound engineering principles and conservatism should pose no serious stability problems during earthquakes in this zone. The seismic stability of an earth dam is dependent upon a number of factors: embankment and foundation material classifications and shear strengths; abutment materials, conditions, and strengths; embankment zoning; and embankment geometry. Adequate descriptions of embankment design parameters, foundation and abutment conditions, or static stability analyses to assess the seismic stability of this embankment were not available and therefore no inferences will be made regarding the seismic stability. An assessment of the seismic stability should be included as part of the stability analysis required by the guidelines.

SECTION 7 - ASSESSMENT/REMEDIAL MEASURES

7.1 DAM ASSESSMENT

a. Safety. Several conditions observed during the visual inspection by the inspection team should be monitored and/or controlled. These are erosion on the left abutment, the right abutment below the spillway, and the right bank of the spillway, and the poor erosion protection on the embankment. Seepage and stability analyses comparable to the requirements of the "Recommended Guidelines for Safety Inspection of Dams" were not available, which is considered a deficiency.

b. Adequacy of Information. Due to the absence of engineering design data, the conclusions in this report were based only on performance history and visual conditions. The inspection team considers that these data are sufficient to support the conclusions herein. Seepage and stability analyses comparable to the requirements of the "Recommended Guidelines for Safety Inspection of Dams" were not available, which is considered a deficiency.

c. Urgency. It is the opinion of the inspection team that a program should be developed as soon as possible to implement remedial measures recommended in paragraph 7.2b. If the safety deficiencies listed in paragraph 7.1a are not corrected, they will continue to deteriorate and lead to a serious potential of failure. The item recommended in paragraph 7.2a should be pursued on a high priority basis.

d. Necessity for Phase II. The Phase I investigation does not raise any serious questions relating to the safety of the dam nor does it identify any serious dangers which would require a Phase II investigation. However, the additional analyses noted in paragraph 2.5b are necessary for compliance with the guidelines.

e. Seismic Stability. This dam is located in Seismic Zone 2. Adequate description of embankment design parameters, foundation and abutment conditions, or static stability analyses to assess the seismic stability of this embankment were not available and therefore no inferences will be made regarding the seismic stability. An assessment of the seismic stability should be included as part of the recommended stability analysis.

7.2 REMEDIAL MEASURES

a. Alternatives. The spillway size and/or height of the dam would need to be increased or the lake level would need to be permanently lowered to increase available flood storage in order to effectively pass the recommended spillway design flood.

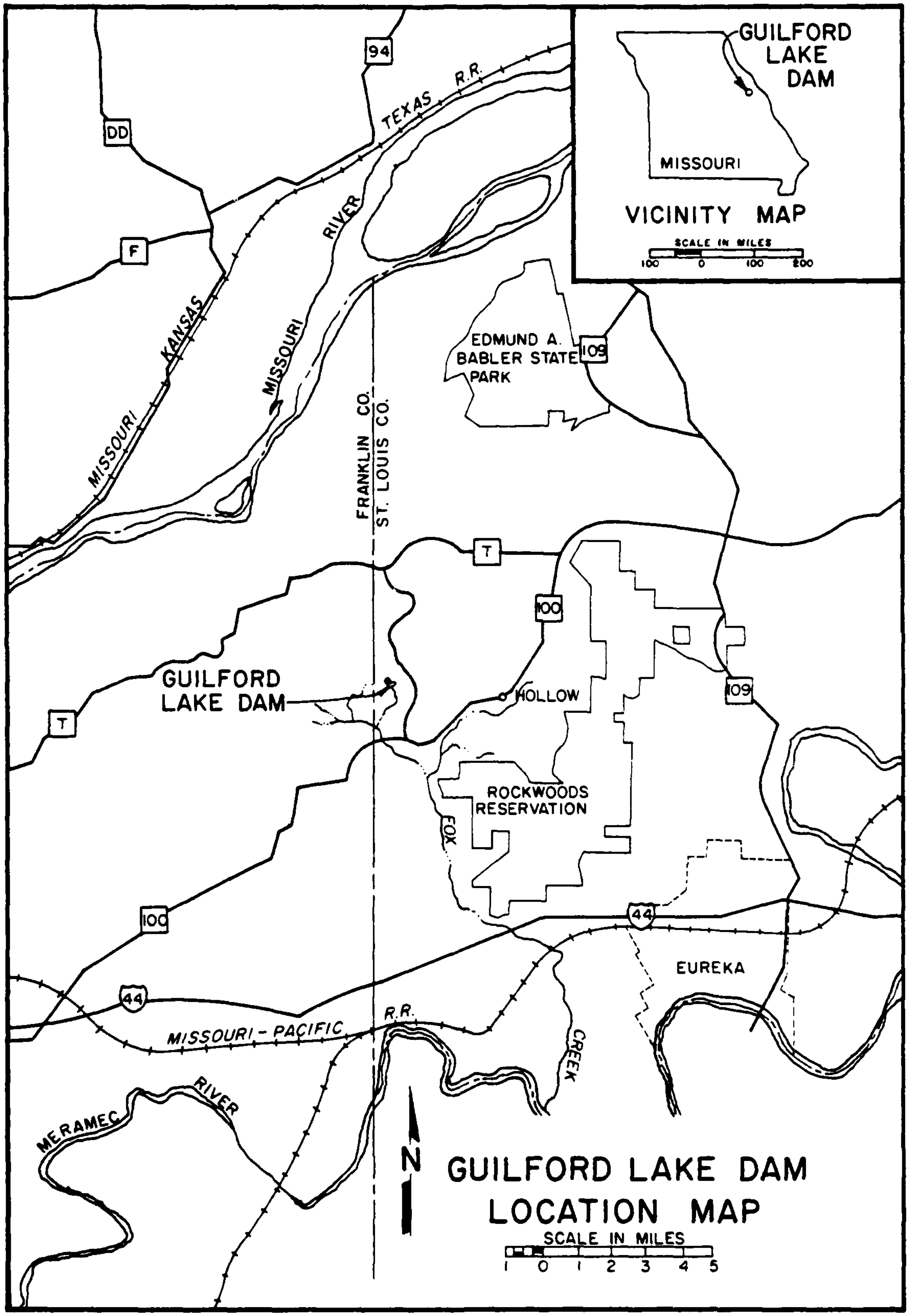
b. Operation and Maintenance Procedures. The following operation and maintenance procedures are recommended and should be carried out under the direction of a professional engineer experienced in the design, construction, and maintenance of earth dams.

(1) An adequate grass cover should be maintained on the embankment and in the spillway to prevent erosion. Overgrazing by cattle should be prevented.

(2) The erosion of the right spillway bank, the left abutment, and the right abutment below the spillway should be backfilled with suitable material and compacted. A paved ditch or some other means of slope protection may be required to control the concentrated runoff at the left abutment.

(3) Seepage and stability analyses should be performed.

(4) A detailed inspection of the dam should be made periodically and the results documented and made a matter of record. More frequent inspections may be required if additional deficiencies are observed or the severity of the reported deficiencies increase.


GUILFORD
LAKE
DAM
MISSOURI
VICINITY MAP
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RIVER
MISSOURI
MISSOURI KANSAS
EDMUND A.
BABLER STATE
PARK
109
FRANKLIN CO.
ST. LOUIS CO.
T
100
GUILFORD
LAKE DAM
HOLLOW
109
ROCKWOODS
RESERVATION
FOX
44
EUREKA
MISSOURI - PACIFIC R.R.
CREEK
MERAMEC RIVER
N
GUILFORD LAKE DAM
LOCATION MAP
SCALE IN MILES
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PLATE I

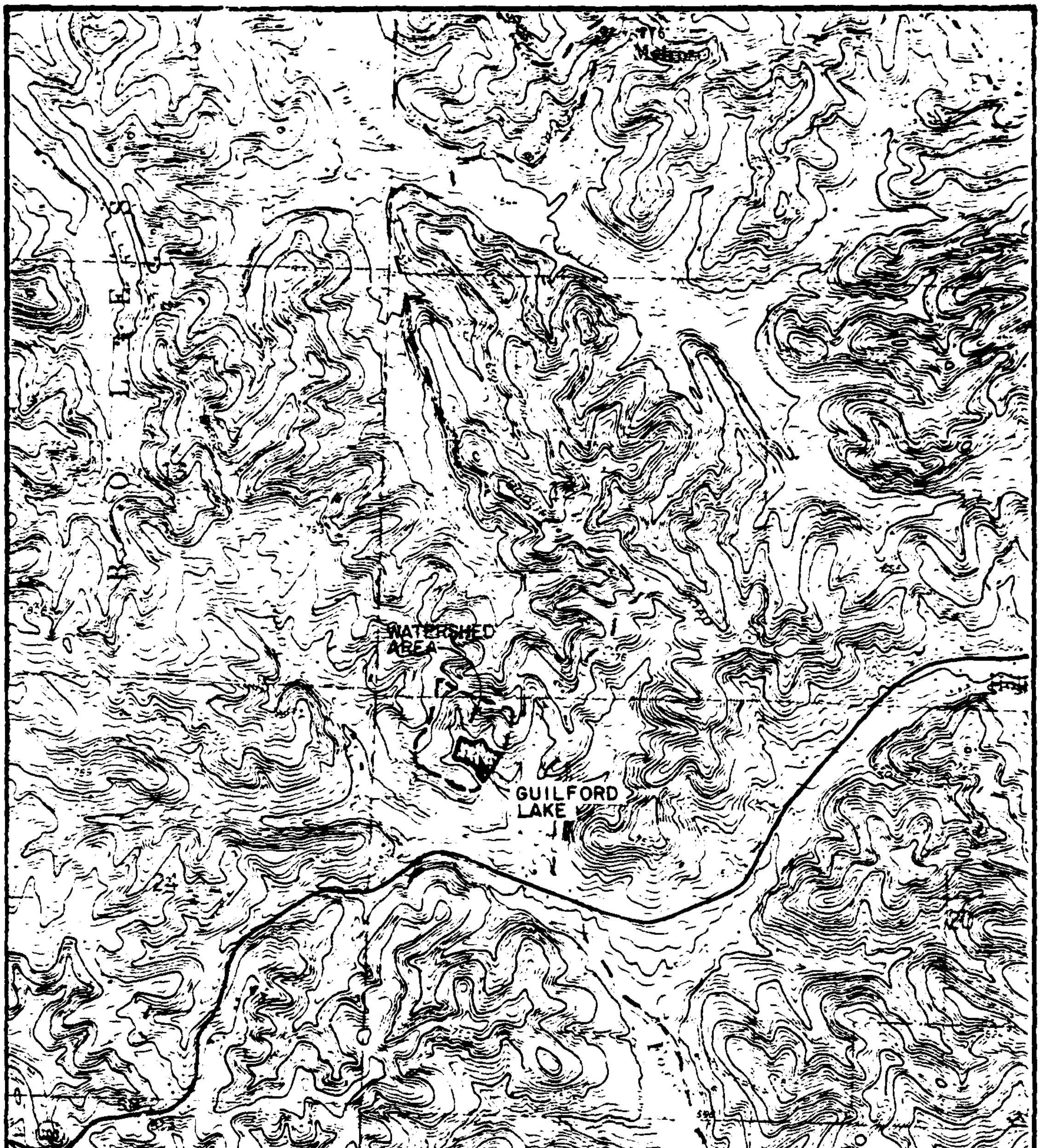
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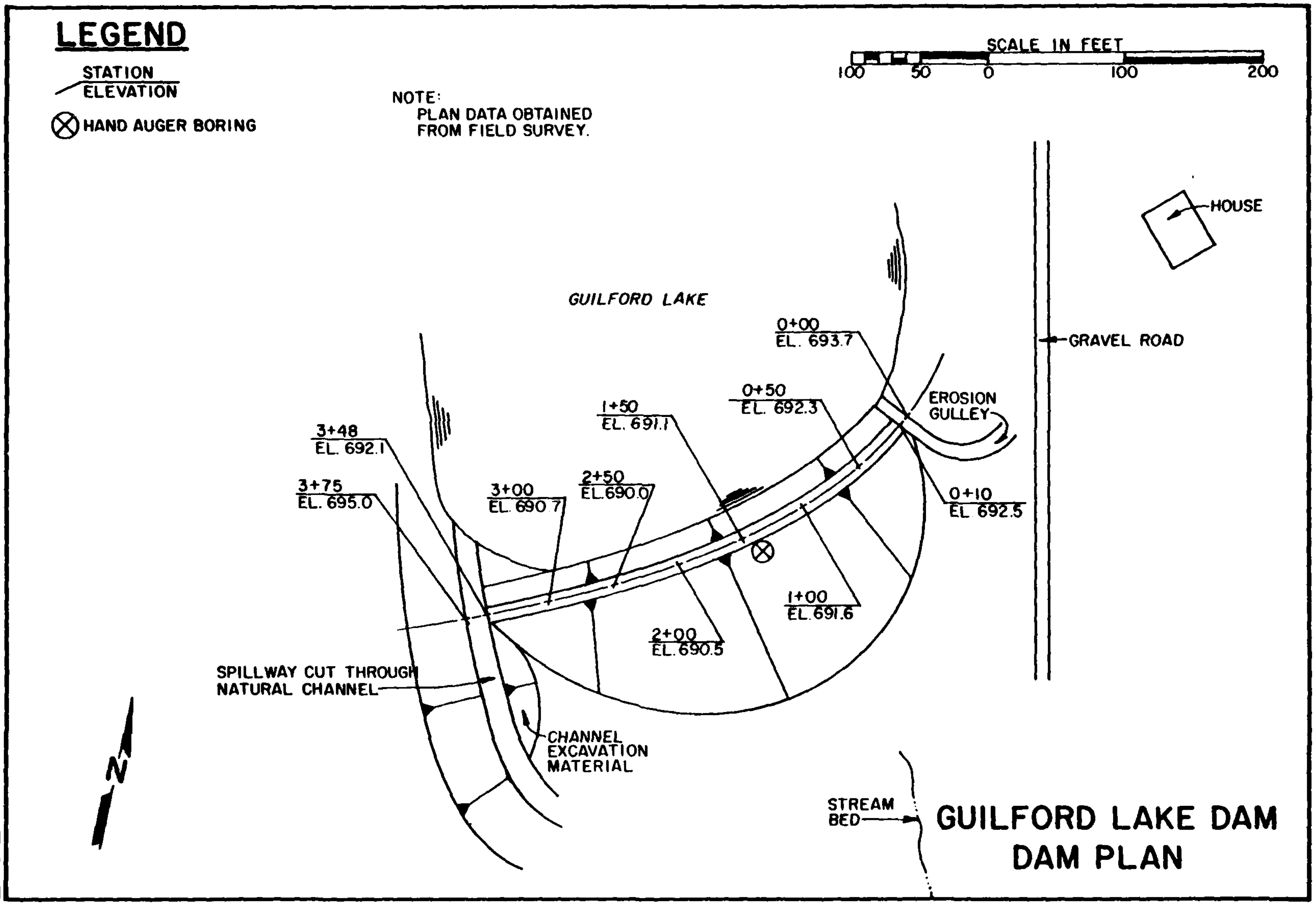
PLATE 2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STATION
ELEVATION
HAND AUGER BORING
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HOUSE
GUILFORD LAKE
GRAVEL ROAD
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EL. 693.7
0+50
EL. 692.3
1+50
EL. 691.1
EROSION
GULLEY
3+48
EL. 692.1
3+75
EL. 695.0
3+00
EL. 690.7
2+50
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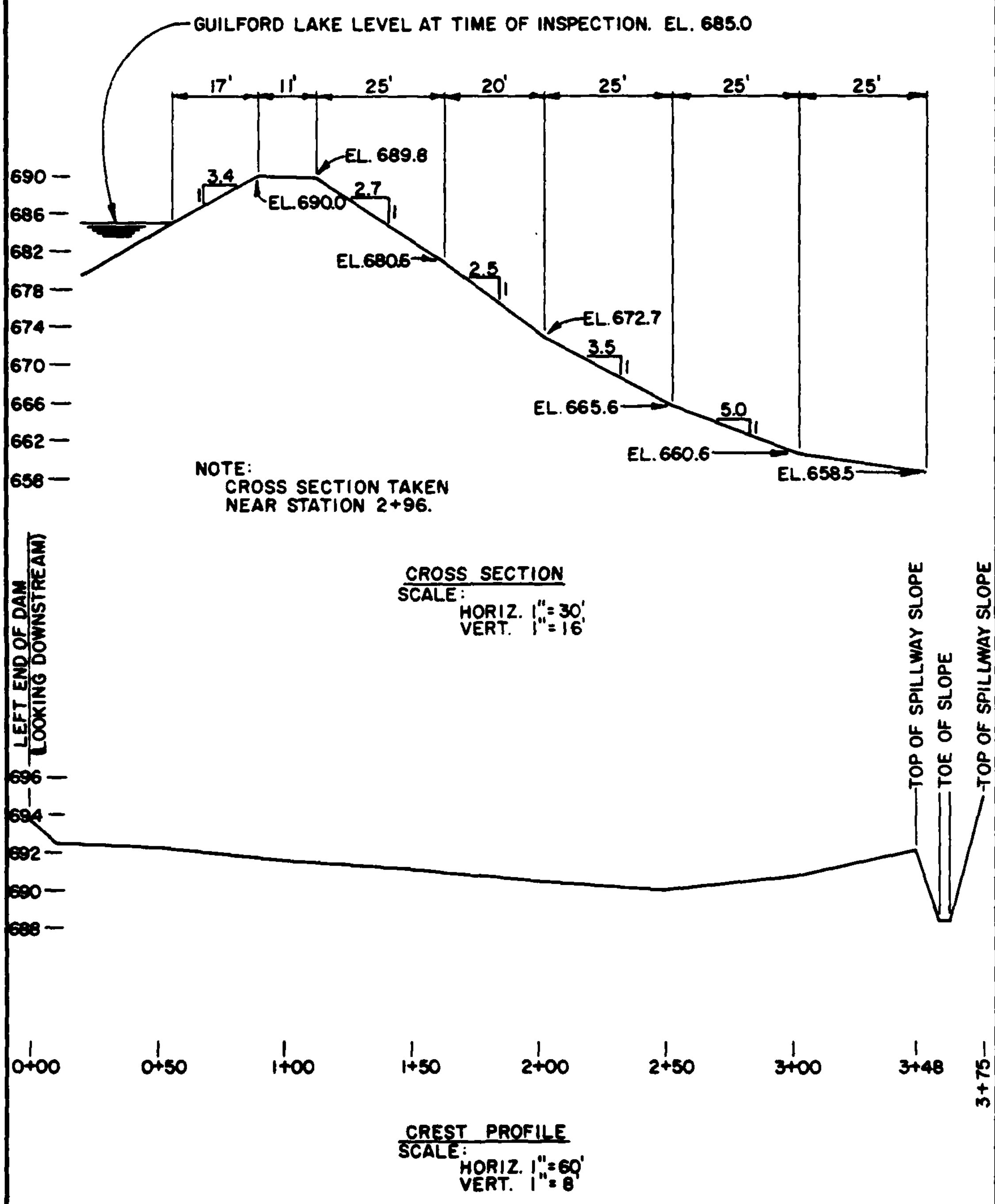
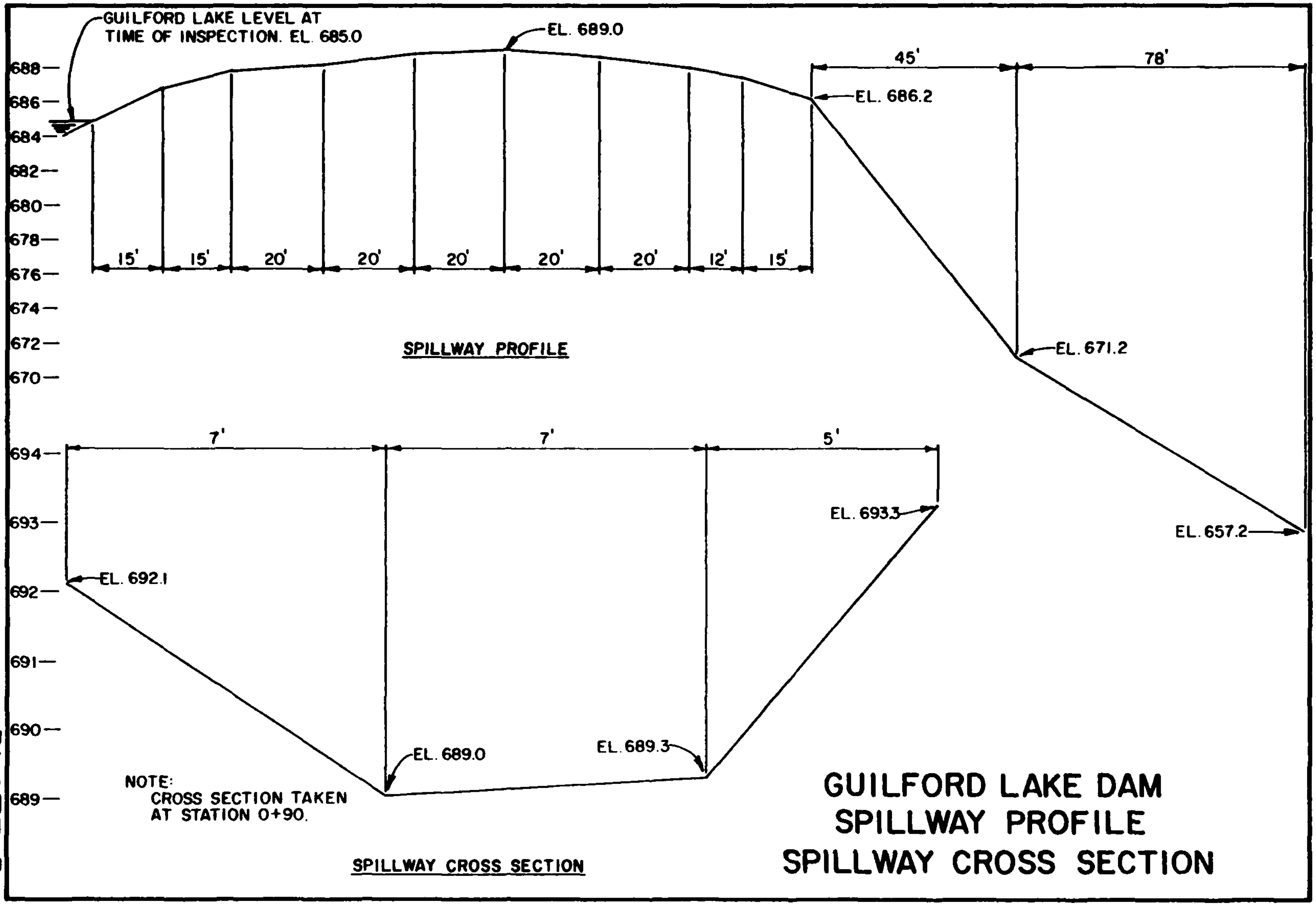
EL. 692.5
1+00
EL. 691.6
2+00
EL. 690.5
SPILLWAY CUT THROUGH
NATURAL CHANNEL
CHANNEL
EXCAVATION
MATERIAL
N
STREAM
BED
GUILFORD LAKE DAM
DAM PLAN

PLATE 3



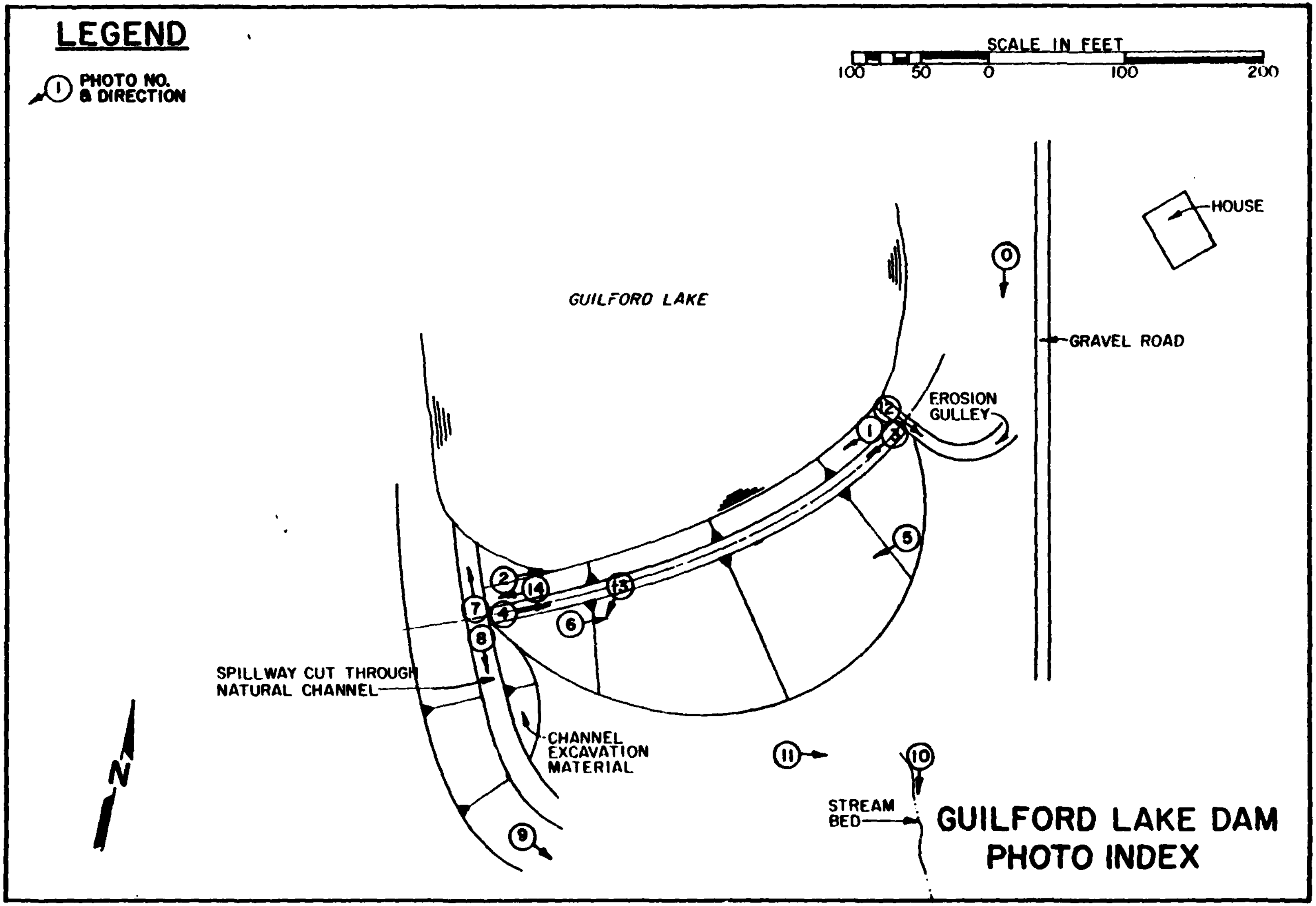
GUILFORD LAKE DAM
DAM CROSS SECTION
DAM CREST PROFILE

PLATE 4



GUILFORD LAKE DAM
SPILLWAY PROFILE
SPILLWAY CROSS SECTION

PLATE 5



GUILFORD LAKE DAM
PHOTO INDEX

PLATE 6

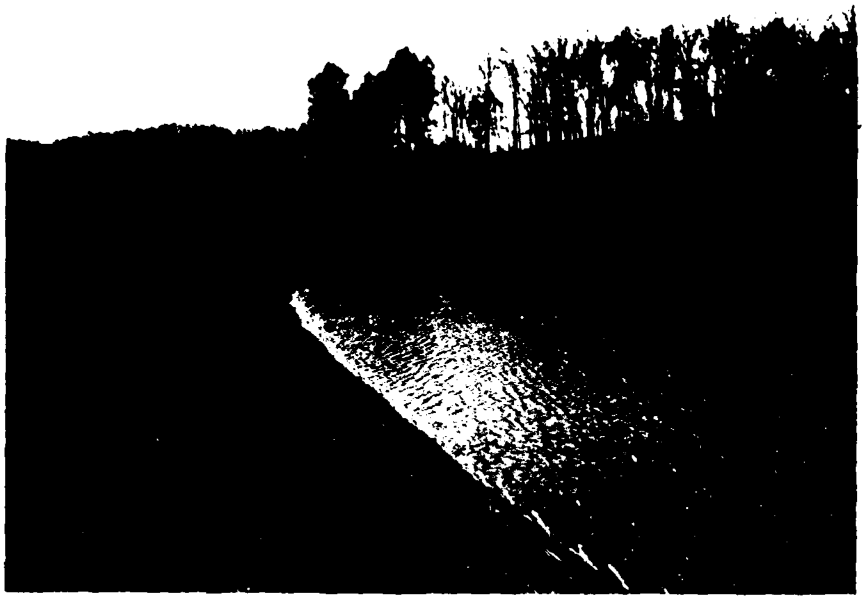


PHOTO 1: UPSTREAM FACE OF DAM LOOKING SOUTH

PHOTO 2: UPSTREAM FACE OF DAM LOOKING NORTH

PHOTO 3: CREST OF DAM LOOKING SOUTH

PHOTO 4: CREST OF DAM LOOKING NORTH

PHOTO 5: DOWNSTREAM FACE OF DAM LOOKING SOUTH

PHOTO 6: DOWNSTREAM FACE OF DAM LOOKING NORTH

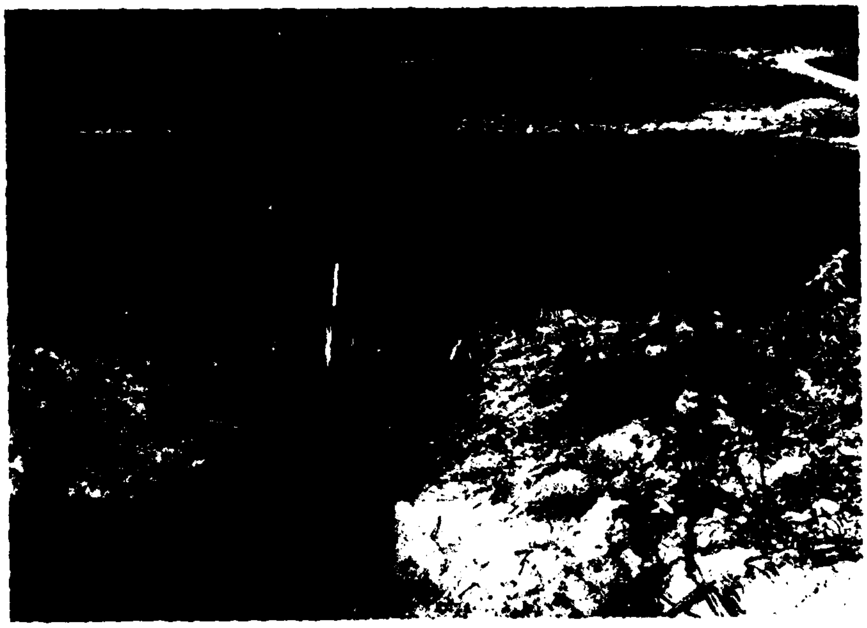


PHOTO 7: INLET TO SPILLWAY CHANNEL

PHOTO 8: SPILLWAY CHANNEL LOOKING DOWNSTREAM

PHOTO 9: EROSION ON ABUTMENT SLOPE DOWNSTREAM OF SPILLWAY CHANNEL

PHOTO 10: STREAM CHANNEL BELOW DAM

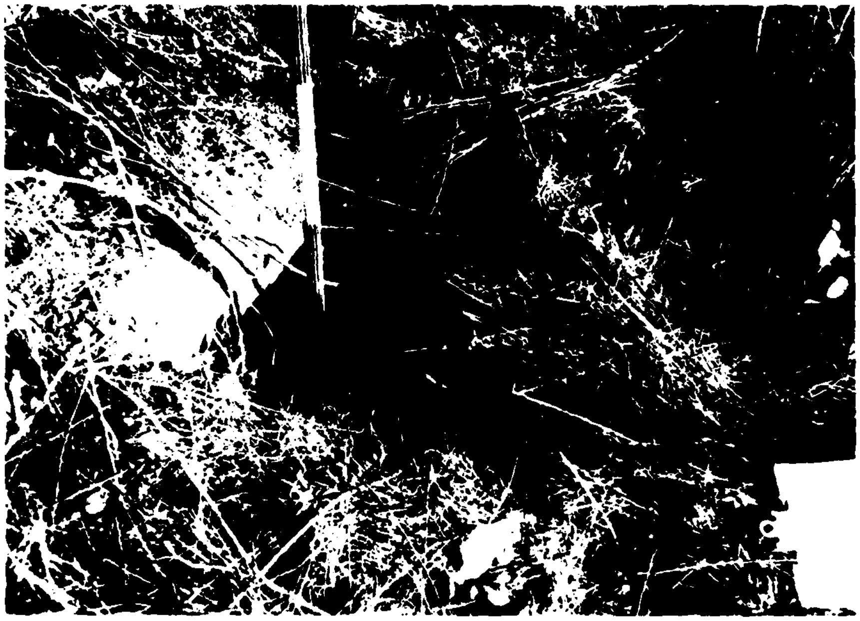


PHOTO 11: VOID IN FILL OF OLD STREAM CHANNEL BELOW DAM

PHOTO 12: EROSION AT LEFT ABUTMENT

PHOTO 13: EROSION ON DOWNSTREAM SLOPE OF DAM

PHOTO 14: LIVESTOCK TRACKS AND OVERGRAZED AREA

APPENDIX A

HYDROLOGIC AND HYDRAULIC ANALYSES

HYDROLOGIC AND HYDRAULIC ANALYSES

To determine the overtopping potential, flood routings were performed by applying the Probable Maximum Precipitation (PMP) to a synthetic unit hydrograph to develop the inflow hydrograph. The inflow hydrograph was then routed through the reservoir and spillway. The overtopping analysis was determined using the computer program HEC-1 (Dam Safety Version) (1).

The PMP was determined from regional charts prepared by the National Weather Service in "Hydrometeorological Report No. 33" (HMR-33) (2). Reduction factors were not applied. The rainfall distribution for the 24-hour PMP storm was determined according to the procedures outlined in HMR-33 and EM 1110-2-1411 (3). The St. Louis, Missouri rainfall distribution (5 min. interval - 24 hours duration), as provided by the St. Louis District, Corp of Engineers, was used when the one percent chance probability flood was routed through the reservoir and spillway.

The synthetic unit hydrograph for the watershed was developed by the computer program using the Soil Conservation Service (SCS) method. (1 and 4). The parameters for the unit hydrograph are shown in Table 1. Lag time and time of concentration were calculated by two different methods. The results used in the analyses were obtained by using the Kirpich formula.

The SCS curve number (CN) method was used in computing the infiltration losses for the rainfall-runoff relationship. The CN values used, and the result from the computer output, are shown in Table 2.

The reservoir routing was performed using the Modified Puls Method. The initial reservoir pool elevation for the routing of each storm was determined to be equivalent to the crest elevation of the spillway at elevation 689.0 feet m.s.l. in accordance with antecedent storm conditions preceding the one percent probability and probable maximum storms outlined by the U.S. Army Corps of Engineers, St. Louis District (5). The hydraulic capacity of the spillway and the storage capacity of the reservoir were defined by the elevation, surface area, storage, and discharge relationships shown in Table 3.

The rating curve for the spillway is shown in Table 4. The flow over the crest of the dam and through the spillway was determined using the non-level dam crest option ($L and $V cards) of the HEC-1 program. The program assumes critical flow over a broad-crested weir.

The result of the routing analysis indicates that a 15 percent PMF flood will not overtop the dam.

A summary of the routing analysis for different ratios of the PMF is shown in Table 5.

The computer input data and a summary of the output data are presented at the back of this appendix.

TABLE 1

SYNTHETIC UNIT HYDROGRAPH

Parameters:

Drainage Area (A)	26 acres
Hydraulic Length of Watercourse (L)	0.16 miles
Difference in Elevation (H)	90 feet
Time of concentration (T_c)	0.05 hours
Lag Time (L_g)	0.03 hours
Duration (D)	0.4 minutes (use 5 minutes)

Time (Min.) *	Discharge (cfs) *
0	0
5	236
10	66
15	13
20	3
25	0

* From HEC-1 computer output

FORMULAS USED:

$$T_c = [(11.9 \times L^3)/H]^{0.385} \quad (6)$$

$$D = 0.133\ T_c$$

$$L_g = 0.6\ T_c$$

TABLE 2

RAINFALL-RUNOFF VALUES

Selected Storm Event	Storm Duration (Hours)	Rainfall (Inches)	Runoff (Inches)	Loss (Inches)
PMP	24	32.89	31.31	1.58
50% PMP	24	17.18	15.65	1.53
1% Probability	24	6.97	4.13	2.84

Additional Data:

1) No information on soil associations was available for this watershed.
   100 percent of the drainage area was assumed to be in hydrologic soil group C.
   35 percent of the land use was grassland.
   65 percent of the land use was timberland.
2) SCS Runoff Curve CN = 88 (AMC III) for the PMF.
3) SCS Runoff Curve CN = 75 (AMC II) for the one percent probability flood (4).

TABLE 3

ELEVATION, SURFACE AREA, STORAGE, AND DISCHARGE RELATIONSHIPS

Elevation (feet-msl)	Lake Surface Area (acres)	Lake Storage (acre-ft)	Spillway Discharge (cfs)
*689.0	4.5	46	0
**690.0	5.7	52	21

*Spillway Crest Elevation
**Top of Dam Elevation

The relationships in Table 3 were developed from the Eureka, Missouri. 7.5 minute quadrangle map and the field measurements.

TABLE 4

SPILLWAY RATING CURVE

Reservoir Elevation (ft-msl)	Spillway Discharge (cfs)
*689.0	0
689.5	4
689.8	12
**690.0	21

*Spillway Crest Elevation
**Top of Dam Elevation

METHOD USED:

Spillway releases were computed by HEC-1 from spillway geometry data input on $L and $V cards. Discharges through the spillway for the probable maximum flood and for 50 percent of the probable maximum flood were determined by the equations for flow over a non-level crest.

$$d_c = 2/3\ (H_m + 1/4\ \Delta Y)$$

$$A = 1/2\ T\ (2d_c - \Delta Y)$$

$$Q = (A^3 g/T)^{0.5}$$

where:

d_c = critical depth (feet)
H_m = available specific energy which is taken to be the height of the water surface in the reservoir above the bottom of the section (feet)
ΔY = change in elevation across the section (feet)
A = flow area (sq. ft.)
T = top width (feet)
Q = flow (cfs)
g = 32.2 ft/sec^2 = acceleration due to gravity.

TABLE 5

RESULTS OF FLOOD ROUTINGS

Ratio of PMF	Peak Inflow (cfs)	Peak Lake Elevation (ft.-msl)	Total Storage (ac.-ft.)	Peak Outflow (cfs)	Depth (ft.) Over Top of Dam	Duration (hrs.) Over Top of Dam
-	0	*689.0	46	0	-	-
0.15	114	690.0	52	21	0	0
0.50	379	690.9	57	212	0.9	5.6
1.00	757	691.4	59	531	1.4	7.2

* Spillway Crest Elevation

BIBLIOGRAPHY

(1) U.S. Army Corps of Engineers, Hydrologic Engineering Center, Flood Hydrograph Package (HEC-1), Dam Safety Version, July 1978, Davis, California.

(2) HMR-33, Seasonal Variations of Probable Maximum Precipitation, East of the 105th Meridian for Areas 10 to 1000 Square Miles and Durations from 6 to 48 Hours, U.S. Department of Commerce, NOAA, National Weather Service, 1956.

(3) EM-1110-2-1411, Standard Project Flood Determinations, U.S. Army Corps of Engineers, 26 March 1952.

(4) U.S. Department of Agriculture, Soil Conservation Service, National Engineering Handbook, Section 4, Hydrology, August 1972.

(5) U.S. Army Corps of Engineers, St. Louis District, Hydrologic/ Hydraulic Standards, Phase I Safety Inspection of Non-Federal Dams, 12 December 1979.

(6) U.S. Department of the Interior, Bureau of Reclamation, Design of Small Dams, 1974, Washington, D.C.

(7) U.S. Department of Agriculture, Soil Conservation Service, Soil Survey Interpretations and Field Maps, 1980.

(8) Mary H. McCracken, Missouri Division of Geological Survey, Geologic Map of Missouri, 1961.

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*********************************
FLOOD HYDROGRAPH PACKAGE (HEC-1)
DAM SAFETY VERSION      JULY 1978
  LAST MODIFICATION  01 APR 80
*********************************
A1MISSOURI DAM INSPECTION PROGRAM
A2ST. LOUIS DISTRICT US ARMY CORPS OF ENGR
A3GUILFORD LAKE DAM  (PMF)
B    288       0       5       0       0       0       0       0       0       0
B1     5
J      1       9       1
J1   .05      .1     .15      .2     .25      .3     .35      .5     1.0
K      0       1                               3       1
K1   GUILFORD LAKE (24 HR. PROBABLE MAXIMUM RUNOFF)
M      1       2    .041                       1
P           25.3     101     120     130
T                                                     -1     -88
W2          .032
A                      1
K      1       2                                       1
K1   ROUTE THROUGH SPILLWAY
Y                              1       1
Y1     1                                            -689.
SA    0.     4.5     5.7     7.9
SE  655.    689.    693.    700.
SS  689.
SD  693.
SL    0.     7.5     11.     98.    134.    179.    247.    302.    356.386.
SV  689.   689.8    690.   690.5   690.7   691.1   691.6   692.1   692.5695.
K     99
A1MISSOURI DAM INSPECTION PROGRAM
A2ST. LOUIS DISTRICT US ARMY CORPS OF ENGR
A3GUILFORD LAKE DAM  (100-YR)
B    288               5
B1     3
K      0       1                               3       1
K1   GUILFORD LAKE (24 HR. 100-YEAR INFLOW)
M      0       2    .041
O    288   6.974
O1  .007    .007    .007    .007    .007    .007    .007    .007    .007    .007
O1  .007    .007    .007    .007    .007    .007    .007    .007    .007    .007
O1  .007    .007    .007    .007    .007    .007    .007    .007    .007    .007
O1  .007    .007    .007    .007    .007    .007    .007    .007    .007    .007
O1  .007    .007    .007    .007    .007    .007    .007    .007    .007    .007
O1  .007    .007    .007    .007    .007    .007    .007    .007    .007    .007
O1  .007    .007    .007    .007    .007    .007    .007    .007    .007    .007
O1  .007    .007    .012    .012    .012    .012    .012    .012    .012    .012
O1  .012    .012    .012    .012    .012    .012    .012    .012    .012    .012
O1  .012    .012    .012    .012    .012    .012    .012    .012    .012    .012
O1  .012    .012    .012    .012    .012    .012    .012    .012    .023    .023
O1  .023    .023    .023    .023    .023    .023    .023    .023    .023    .023
O1  .023    .023    .023    .023    .023    .023    .030    .030    .030    .030
O1  .030    .030    .049    .049    .048    .049    .049    .049    .134    .134
O1  .134    .255    .255    .546    .817    .389    .255    .134    .134    .134
O1  .049    .049    .049    .049    .048    .048    .030    .030    .030    .030
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D L A     C U L A T C H                                                          PROJECT 9160:      DATE 30 DEC       PAGE      3
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     56                  01  .012    .012    .012    .012    .012    .012    .007    .007    .007    .007
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     63                  01  .007    .007    .007    .007    .007    .007    .007    .007
     64                  T                                                  -1     -75
     65                  W2          .032
     66                  K                       1
     67                  K      1       2                                    1
     68                  KT  ROUTE THROUGH SPILLWAY
     69                  Y                               1
     70                  Y1     1                                        -689.
     71                  SA    0.     4.5     5.7     7.9
     72                  SE  658.    689.    690.    700.
     73                  SS  689.
     74                  SD  690.
     75                  SL    0.     7.5     11.     96.    134.    179.    247.    302.    358.396.
     76                  SV  689.   689.3    690.   690.5   690.7   691.1   691.6   692.1   692.5695.
     77                  K     99
     78                  A
     79                  A
     80                  A
     81                  A
     82                  A
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        FLOOD HYDROGRAPH PACKAGE (HEC-1)
        DAM SAFETY VERSION      JULY 1978
          LAST MODIFICATION  01 APR 80
        ********************************
                     MISSOURI DAM INSPECTION PROGRAM
                     ST. LOUIS DISTRICT US ARMY CORPS OF ENGR
                     GUILFORD LAKE DAM  (PMF)

                                            JOB SPECIFICATION
                      NQ     NHR    NMIN   IDAY    IHR    IMIN   METRC   IPLT    IPRT   NSTAN
                     288       0       5      3      0       0       0      0       0       0
                                          JOPER    NWT   LROPT   TRACE
                                              5      0       0       0

                                     MULTI-PLAN ANALYSES TO BE PERFORMED
                                        NPLAN= 1 NRTIO= 9 LRTIO= 1
                        RTIOS=    .05    .10    .15    .20    .25    .30    .35    .50   1.00

                **********      **********      **********      **********      **********

                                            SUB-AREA RUNOFF COMPUTATION

                      GUILFORD LAKE (24 HR. PROBABLE MAXIMUM RUNOFF)

                              ISTAQ   ICOMP   IECON   ITAPE    JPLT    JPRT   INAME  ISTAGE   IAUTO
                                  1       0       0       0       0       3       1       0       0

                                            HYDROGRAPH DATA
                      IHYDG    IUHG   TAREA    SNAP   TRSDA   TRSPC   RATIO   ISNOW   ISAME   LOCAL
                          1       2     .04     .00     .04    1.00    .000       0       0       0

                                              PRECIP DATA
                             SPFE     PMS      R6     R12     R24     R48     R72     R96
                              .00   25.30  101.00  120.00  132.00     .00     .00     .00

                                               LOSS DATA
                 LROPT   STRKR   DLTKR   RTIOL   ERAIN   STRKS   RTIOK   STRTL   CNSTL   ALSMX   RTIMP
                     0     .00     .00    1.00     .00     .00    1.00   -1.00  -88.00     .00     .00

                     CURVE NO =  -88.00  WETNESS =    -1.00  EFFECT CN =   88.00

                                         UNIT HYDROGRAPH DATA
                                      TC=    .00    LAG=    .03

                                             RECESSION DATA
                              STRTQ=     .00    QRCSN=     .00    RTIOR= 1.00

                     TIME INCREMENT TOO LARGE--(NHQ IS GT LAG/2)

                    UNIT HYDROGRAPH  5 END OF PERIOD ORDINATES, TC=     .00 HOURS, LAG=    .03  VOL= 1.00
                 236.      66.      17.       3.       0.
```



```
          0                                 END-OF-PERIOD FLOW
```

0
END-OF-PERIOD FLOW

MO.DA	HR.MN	PERIOD	RAIN	EXCS	LOSS	COMP Q	MO.DA	HR.MN	PERIOD	RAIN	EXCS	LOSS	COMP Q
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1.01	.50	10	.01	.00	.01	0.	1.01	12.50	154	.21	.21	.00	66.
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1.01	2.35	31	.01	.00	.01	1.	1.01	14.35	175	.32	.32	.00	100.
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1.01	3.15	39	.01	.00	.01	1.	1.01	15.15	183	.39	.39	.00	120.
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1.01	3.25	41	.01	.00	.01	1.	1.01	15.25	185	.68	.68	.00	204.
1.01	3.30	42	.01	.00	.01	1.	1.01	15.30	186	1.65	1.64	.01	440.
1.01	3.35	43	.01	.00	.01	2.	1.01	15.35	187	2.72	2.71	.01	757.
1.01	3.40	44	.01	.01	.01	2.	1.01	15.40	188	1.07	1.06	.00	453.
1.01	3.45	45	.01	.01	.01	2.	1.01	15.45	189	.68	.65	.00	269.
1.01	3.50	46	.01	.01	.01	2.	1.01	15.50	190	.58	.58	.00	203.
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1.01	4.15	51	.01	.01	.01	2.	1.01	16.15	195	.30	.30	.00	95.
1.01	4.20	52	.01	.01	.01	2.	1.01	16.20	196	.30	.30	.00	94.
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1.01	4.40	56	.01	.01	.01	2.	1.01	16.40	200	.30	.30	.00	94.
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1.01	4.55	59	.01	.01	.01	2.	1.01	16.55	203	.30	.30	.00	94.
1.01	5.00	60	.01	.01	.01	2.	1.01	17.00	204	.30	.30	.00	94.
1.01	5.05	61	.01	.01	.01	2.	1.01	17.05	205	.23	.23	.00	79.
1.01	5.10	62	.01	.01	.01	2.	1.01	17.10	206	.23	.23	.00	75.
1.01	5.15	63	.01	.01	.01	2.	1.01	17.15	207	.23	.23	.00	74.
1.01	5.20	64	.01	.01	.01	2.	1.01	17.20	208	.23	.23	.00	74.
1.01	5.25	65	.01	.01	.01	2.	1.01	17.25	209	.23	.23	.00	74.
1.01	5.30	66	.01	.01	.01	2.	1.01	17.30	210	.23	.23	.00	74.
1.01	5.35	67	.01	.01	.01	2.	1.01	17.35	211	.23	.23	.00	74.
1.01	5.40	68	.01	.01	.01	2.	1.01	17.40	212	.23	.23	.00	74.
1.01	5.45	69	.01	.01	.01	2.	1.01	17.45	213	.23	.23	.00	74.
1.01	5.50	70	.01	.01	.01	3.	1.01	17.50	214	.23	.23	.00	74.
1.01	5.55	71	.01	.01	.01	3.	1.01	17.55	215	.23	.23	.00	74.
1.01	6.00	72	.01	.01	.01	3.	1.01	18.00	216	.23	.23	.00	74.
1.01	6.05	73	.07	.04	.03	10.	1.01	18.05	217	.02	.02	.00	24.
1.01	6.10	74	.07	.04	.03	12.	1.01	18.10	218	.02	.02	.00	10.
1.01	6.15	75	.07	.04	.02	13.	1.01	18.15	219	.02	.02	.00	7.
1.01	6.20	76	.07	.04	.02	14.	1.01	18.20	220	.02	.02	.00	7.
1.01	6.25	77	.07	.05	.02	14.	1.01	18.25	221	.02	.02	.00	7.
1.01	6.30	78	.07	.05	.02	15.	1.01	18.30	222	.02	.02	.00	7.
1.01	6.35	79	.07	.05	.02	15.	1.01	18.35	223	.02	.02	.00	7.
1.01	6.40	80	.07	.05	.02	15.	1.01	18.40	224	.02	.02	.00	7.
1.01	6.45	81	.07	.05	.02	16.	1.01	18.45	225	.02	.02	.00	7.
1.01	6.50	82	.07	.05	.02	16.	1.01	18.50	226	.02	.02	.00	7.
1.01	6.55	83	.07	.05	.02	16.	1.01	18.55	227	.02	.02	.00	7.
1.01	7.00	84	.07	.05	.02	16.	1.01	19.00	228	.02	.02	.00	7.
1.01	7.05	85	.07	.05	.01	17.	1.01	19.05	229	.02	.02	.00	7.
1.01	7.10	86	.07	.05	.01	17.	1.01	19.10	230	.02	.02	.00	7.
1.01	7.15	87	.07	.05	.01	17.	1.01	19.15	231	.02	.02	.00	7.
1.01	7.20	88	.07	.05	.01	17.	1.01	19.20	232	.02	.02	.00	7.
1.01	7.25	89	.07	.05	.01	17.	1.01	19.25	233	.02	.02	.00	7.
1.01	7.30	90	.07	.06	.01	17.	1.01	19.30	234	.02	.02	.00	7.
1.01	7.35	91	.07	.06	.01	18.	1.01	19.35	235	.02	.02	.00	7.
1.01	7.40	92	.07	.06	.01	18.	1.01	19.40	236	.02	.02	.00	7.
1.01	7.45	93	.07	.06	.01	18.	1.01	19.45	237	.02	.02	.00	7.
1.01	7.50	94	.07	.06	.01	18.	1.01	19.50	238	.02	.02	.00	7.
1.01	7.55	95	.07	.06	.01	18.	1.01	19.55	239	.02	.02	.00	7.
1.01	8.00	96	.07	.06	.01	18.	1.01	20.00	240	.02	.02	.00	7.
1.01	8.05	97	.07	.06	.01	18.	1.01	20.05	241	.02	.02	.00	7.
1.01	8.10	98	.07	.05	.01	18.	1.01	20.10	242	.02	.02	.00	7.
1.01	8.15	99	.07	.05	.01	19.	1.01	20.15	243	.02	.02	.00	7.
1.01	8.20	100	.07	.06	.01	19.	1.01	20.20	244	.02	.02	.00	7.
1.01	8.25	101	.07	.06	.01	19.	1.01	20.25	245	.02	.02	.00	7.
1.01	8.30	102	.07	.06	.01	19.	1.01	20.30	246	.02	.02	.00	7.
1.01	8.35	103	.07	.06	.01	19.	1.01	20.35	247	.02	.02	.00	7.
1.01	8.40	104	.07	.06	.01	19.	1.01	20.40	248	.02	.02	.00	7.
1.01	8.45	105	.07	.06	.01	19.	1.01	20.45	249	.02	.02	.00	7.
1.01	8.50	106	.07	.06	.01	19.	1.01	20.50	250	.02	.02	.00	7.
1.01	8.55	107	.07	.06	.01	19.	1.01	20.55	251	.02	.02	.00	7.
1.01	9.00	108	.07	.06	.01	19.	1.01	21.00	252	.02	.02	.00	7.
1.01	9.05	109	.07	.06	.01	19.	1.01	21.05	253	.02	.02	.00	7.

1.01	9.10	110	.07	.06	.01	19.	1.01	21.10	254	.02	.02	.00	7.

1.01	9.10	110	.07	.06	.01	19.	1.01	21.10	254	.02	.02	.00	7.
1.01	9.15	111	.07	.06	.01	19.	1.01	21.15	255	.02	.02	.00	7.
1.01	9.20	112	.07	.06	.01	19.	1.01	21.20	256	.02	.02	.00	7.
1.01	9.25	113	.07	.06	.01	19.	1.01	21.25	257	.02	.02	.00	7.
1.01	9.30	114	.07	.06	.01	20.	1.01	21.30	258	.02	.02	.00	7.
1.01	9.35	115	.07	.06	.01	20.	1.01	21.35	259	.02	.02	.00	7.
1.01	9.40	116	.07	.06	.00	20.	1.01	21.40	260	.02	.02	.00	7.
1.01	9.45	117	.07	.06	.00	20.	1.01	21.45	261	.02	.02	.00	7.
1.01	9.50	118	.07	.06	.00	20.	1.01	21.50	262	.02	.02	.00	7.
1.01	9.55	119	.07	.06	.00	20.	1.01	21.55	263	.02	.02	.00	7.
1.01	10.00	120	.07	.06	.00	20.	1.01	22.00	264	.02	.02	.00	7.
1.01	10.05	121	.07	.06	.00	20.	1.01	22.05	265	.02	.02	.00	7.
1.01	10.10	122	.07	.06	.00	20.	1.01	22.10	266	.02	.02	.00	7.
1.01	10.15	123	.07	.06	.00	20.	1.01	22.15	267	.02	.02	.00	7.
1.01	10.20	124	.07	.06	.00	20.	1.01	22.20	268	.02	.02	.00	7.
1.01	10.25	125	.07	.06	.00	20.	1.01	22.25	269	.02	.02	.00	7.
1.01	10.30	126	.07	.06	.00	20.	1.01	22.30	270	.02	.02	.00	7.
1.01	10.35	127	.07	.06	.00	20.	1.01	22.35	271	.02	.02	.00	7.
1.01	10.40	128	.07	.06	.00	20.	1.01	22.40	272	.02	.02	.00	7.
1.01	10.45	129	.07	.06	.00	20.	1.01	22.45	273	.02	.02	.00	7.
1.01	10.50	130	.07	.06	.00	20.	1.01	22.50	274	.02	.02	.00	7.
1.01	10.55	131	.07	.05	.00	20.	1.01	22.55	275	.02	.02	.00	7.
1.01	11.00	132	.07	.06	.00	20.	1.01	23.00	276	.02	.02	.00	7.
1.01	11.05	133	.07	.06	.00	20.	1.01	23.05	277	.02	.02	.00	7.
1.01	11.10	134	.07	.05	.00	20.	1.01	23.10	278	.02	.02	.00	7.
1.01	11.15	135	.07	.06	.00	20.	1.01	23.15	279	.02	.02	.00	7.
1.01	11.20	136	.07	.06	.00	20.	1.01	23.20	280	.02	.02	.00	7.
1.01	11.25	137	.07	.06	.00	20.	1.01	23.25	281	.02	.02	.00	7.
1.01	11.30	138	.07	.06	.00	20.	1.01	23.30	282	.02	.02	.00	7.
1.01	11.35	139	.07	.06	.00	20.	1.01	23.35	283	.02	.02	.00	7.
1.01	11.40	140	.07	.06	.00	20.	1.01	23.40	284	.02	.02	.00	7.
1.01	11.45	141	.07	.06	.00	20.	1.01	23.45	285	.02	.02	.00	7.
1.01	11.50	142	.07	.06	.00	20.	1.01	23.50	286	.02	.02	.00	7.
1.01	11.55	143	.07	.06	.00	20.	1.01	23.55	287	.02	.02	.00	7.
1.01	12.00	144	.07	.06	.00	20.	1.02	.00	288	.02	.02	.00	7.

SUM 32.89 31.31 1.58 9948.
(835.)(795.)(40.)(281.70)

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	757.	111.	34.	34.	9930.
CMS	21.	3.	1.	1.	281.
INCHES		25.24	31.29	31.29	31.29
MM		641.13	794.80	794.80	794.80
AC-FT		55.	68.	68.	68.
THOUS CU M		68.	84.	84.	84.

HYDROGRAPH AT STA 1 FOR PLAN 1, RTIO 1

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	38.	6.	2.	2.	496.
CMS	1.	0.	0.	0.	14.
INCHES		1.26	1.56	1.56	1.56
MM		32.06	39.74	39.74	39.74

AC-FT		3.	3.	3.	3.
THOUS CU M		3.	4.	4.	4.

HYDROGRAPH AT STA 1 FOR PLAN 1, RTIO 2

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	76.	11.	3.	3.	993.
CMS	2.	0.	0.	0.	28.
INCHES		2.52	3.13	3.13	3.13
MM		64.11	79.48	79.48	79.48
AC-FT		6.	7.	7.	7.
THOUS CU M		7.	8.	8.	8.

HYDROGRAPH AT STA 1 FOR PLAN 1, RTIO 3

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	114.	17.	5.	5.	1489.
CMS	3.	0.	0.	0.	42.
INCHES		3.79	4.69	4.69	4.69
MM		96.17	119.22	119.22	119.22
AC-FT		8.	10.	10.	10.
THOUS CU M		10.	13.	13.	13.

HYDROGRAPH AT STA 1 FOR PLAN 1, RTIO 4

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	151.	22.	7.	7.	1986.
CMS	4.	1.	0.	0.	56.
INCHES		5.05	6.26	6.26	6.26
MM		128.23	158.96	158.96	158.96
AC-FT		11.	14.	14.	14.
THOUS CU M		14.	17.	17.	17.

HYDROGRAPH AT STA 1 FOR PLAN 1, RTIO 5

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	189.	28.	9.	9.	2482.
CMS	5.	1.	0.	0.	70.
INCHES		6.31	7.82	7.82	7.82
MM		160.28	198.70	198.70	198.70
AC-FT		14.	17.	17.	17.
THOUS CU M		17.	21.	21.	21.

HYDROGRAPH AT STA 1 FOR PLAN 1, RTIO 6

PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME

CFS	227.	73.	70.	10.	2979.
CMS	6.	1.	0.	0.	84.
INCHES		7.57	9.39	9.39	9.39
MM		192.34	238.44	238.44	238.44
AC-FT		17.	21.	21.	21.
THOUS CU M		21.	25.	25.	25.

HYDROGRAPH AT STA 1 FOR PLAN 1, RTIO 7

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	245.	39.	12.	12.	3475.
CMS	8.	1.	0.	0.	98.
INCHES		8.57	10.95	10.95	10.95
MM		224.40	278.18	278.18	278.18
AC-FT		19.	24.	24.	24.
THOUS CU M		24.	30.	30.	30.

HYDROGRAPH AT STA 1 FOR PLAN 1, RTIO 8

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	379.	56.	17.	17.	4965.
CMS	11.	2.	0.	0.	141.
INCHES		12.62	15.65	15.65	15.65
MM		320.57	397.40	397.40	397.40
AC-FT		28.	34.	34.	34.
THOUS CU M		34.	42.	42.	42.

HYDROGRAPH AT STA 1 FOR PLAN 1, RTIO 9

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	757.	111.	34.	34.	9930.
CMS	21.	3.	1.	1.	281.
INCHES		25.24	31.29	31.29	31.29
MM		641.13	794.80	794.80	794.80
AC-FT		55.	68.	68.	68.
THOUS CU M		68.	84.	84.	84.

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HYDROGRAPH ROUTING

ROUTE THROUGH SPILLWAY

ISTAQ	ICOMP	IECON	ITAPE	JPLT	JPRT	INAME	ISTAGE	IAUTO
2	1	0	0	0	0	1	0	0

ROUTING DATA

QLOSS	CLOSS	AVG	IRES	ISAME	IOPT	IPMP	LSTR
.0	.000	.00	1	1	0	0	0

NSTPS	NSTDL	LAG	AMSKK	X	TSK	STORA	ISPRAT
1	0	0	.000	.000	.000	-689.	0

SURFACE AREA=	0.	4.	6.	8.
CAPACITY=	0.	46.	52.	119.
ELEVATION=	659.	689.	690.	700.

CREL	SPWID	COQW	EXPW	ELEVL	COQL	CAREA	EXPL
689.0	.0	.0	.0	.0	.0	.0	.0

DAM DATA

TOPEL	COQD	EXPD	DAMWID
690.0	.0	.0	0.

CREST LENGTH AT OR BELOW	0.	9.	11.	98.	134.	179.	247.	302.	358.	386.
ELEVATION	689.0	689.3	690.0	690.5	690.7	691.1	691.6	692.1	692.5	695.0

STATION 2, PLAN 1, RATIO 1

END-OF-PERIOD HYDROGRAPH ORDINATES

OUTFLOW

0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
0.	0.	0.	0.	0.	0.	1.	1.	1.	1.
1.	1.	1.	1.	1.	1.	1.	1.	1.	1.
1.	1.	1.	1.	1.	2.	2.	3.	3.	4.
4.	4.	4.	4.	4.	4.	4.	4.	4.	4.
4.	4.	4.	4.	4.	4.	4.	4.	4.	4.
4.	4.	4.	4.	4.	4.	4.	4.	4.	4.
4.	4.	3.	3.	3.	3.	3.	3.	3.	3.
3.	3.	3.	3.	3.	3.	3.	3.	2.	2.
2.	2.	2.	2.	2.	2.	2.	2.	2.	2.
2.	2.	2.	2.	2.	2.	2.	2.	2.	2.
2.	2.	2.	2.	2.	2.	2.	2.	2.	2.
2.	1.	1.	1.	1.	1.	1.	1.	1.	1.

AC-FT	53.	65.	65.	65.
THOUS CU M	66.	80.	80.	80.

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PEAK FLOW AND STORAGE (END OF PERIOD) SUMMARY FOR MULTIPLE PLAN-RATIO ECONOMIC COMPUTATIONS
FLOWS IN CUBIC FEET PER SECOND (CUBIC METERS PER SECOND)
AREA IN SQUARE MILES (SQUARE KILOMETERS)

				RATIOS APPLIED TO FLOWS								
OPERATION	STATION	AREA	PLAN	RATIO 1 .05	RATIO 2 .10	RATIO 3 .15	RATIO 4 .20	RATIO 5 .25	RATIO 6 .30	RATIO 7 .35	RATIO 8 .50	RATIO 9 1.00
HYDROGRAPH AT	1	.04	1	38.	76.	114.	151.	189.	227.	265.	379.	757.
	(	.11)	(	1.07)(	2.14)(	3.22)(	4.29)(	5.36)(	6.43)(	7.50)(	10.72)(	21.44)
ROUTED TO	2	.04	1	4.	12.	21.	34.	56.	85.	116.	212.	531.
	(	.11)	(	.11)(	.35)(	.58)(	.97)(	1.58)(	2.39)(	3.28)(	6.00)(	15.03)

SUMMARY OF DAM SAFETY ANALYSIS

PLAN 1 ....

	INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
ELEVATION	689.00	689.00	690.00
STORAGE	46.	46.	52.
OUTFLOW	0.	0.	21.

RATIO OF PMF	MAXIMUM RESERVOIR W.S.ELEV	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS
.05	689.46	.00	49.	4.	.00	17.08	.00
.10	689.75	.00	50.	17.	.00	16.00	.00
.15	690.09	.09	52.	21.	.17	15.92	.00
.20	690.21	.21	53.	34.	2.33	15.92	.00
.25	690.38	.38	54.	56.	2.83	15.83	.00
.30	690.52	.52	55.	85.	3.50	15.75	.00
.35	690.63	.63	55.	116.	4.17	15.75	.00
.50	690.86	.86	57.	212.	5.58	15.67	.00
1.00	691.35	1.35	59.	531.	7.17	15.67	.00

AFIN

DATE
ILME